4:0 Rec'd PCT/PTO 12 SEP 2001

FORM PTO-1390 (REV. 11-2000) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY 'S DOCKET NUMBER 11150/38
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		U S APPLICATION NO (If known, see 37 CFR 1 5 09/936412
INTERNATIONAL APPLICATION NO. PCT/EP00/01936	INTERNATIONAL FILING DATE MARCH 6, 2000	PRIORITY DATE CLAIMED MARCH 11, 1999

TITLE OF INVENTION
DEVICE WITH AT LEAST ONE LASER SENSOR AND METHOD OF OPERATING A LASER SENSOR

APPLICANT(S) FOR DO/EO/US
ANDREAS BASTIAN; ARTHUR SCHNEIDER

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [x] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [x] This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. [x] The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. [x] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   - a. [x] is attached hereto (required only if not communicated by the International Bureau).
   - b. [ ] has been communicated by the International Bureau.
   - c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [ ] An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   - a. [ ] is attached hereto.
   - b. [ ] has been previously submitted under 35 U.S.C. 154(d)(4).
7. [ ] Amendments to the claims of the International Aplication under PCT Article 19 (35 U.S.C. 371(c)(3))
   - a. [ ] are attached hereto (required only if not communicated by the International Bureau).
   - b. [ ] have been communicated by the International Bureau.
   - c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   - d. [ ] have not been made and will not be made.
8. [ ] An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
9. [ ] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [ ] An English lanugage translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. [ ] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [ ] A FIRST preliminary amendment.
14. [ ] A SECOND or SUBSEQUENT preliminary amendment.
15. [ ] A substitute specification.
16. [ ] A change of power of attorney and/or address letter.
17. [ ] A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. [ ] A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. [ ] A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. [ ] Other items or information:

EF291037241US

JC03 Rec'd PCT/PTO 12 SEP 2001

U.S. APPLICATION NO (if known, see 37 CFR 1.5) 09/936412	INTERNATIONAL APPLICATION NO PCT/EP00/01936	ATTORNEY'S DOCKET NUMBER 11150/38

21. ☑ The following fees are submitted:	CALCULATIONS	PTO USE ONLY
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1000.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$860.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$710.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$690.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 860	00
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☒ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$ 130	00

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	$	
Total claims	- 20 =		x **$18.00**	$	
Independent claims	- 3 =		x **$80.00**	$	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$270.00**	$	

TOTAL OF ABOVE CALCULATIONS =	$	
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2. +	$	
SUBTOTAL =	$	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☒ 30 months from the earliest claimed priority date (37 CFR 1.492(f)).	$ 130	00
TOTAL NATIONAL FEE =	$ 1,120	00
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +	$	
TOTAL FEES ENCLOSED =	$ 1,120	00
	Amount to be refunded:	$
	charged:	$

a. ☐ A check in the amount of $ ______________ to cover the above fees is enclosed.

b. ☒ Please charge my Deposit Account No. 11-0600 in the amount of $ 1,120 to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 11-0600 . A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

RICHARD L. MAYER
KENYON & KENYON
ONE BROADWAY
NEW YORK, NEW YORK 10004

[signature]
SIGNATURE

CLIFFORD A. ULRICH
NAME

42,194
REGISTRATION NUMBER

EF 291037241 US

COMBINED DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below adjacent to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled **DEVICE HAVING AT LEAST ONE LASER SENSOR AND A METHOD FOR OPERATING A LASER SENSOR** the specification of which:

[X] is attached hereto;.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a). I hereby claim foreign priority benefits under Title 35, United States Code § 119 of any foreign application(s) for patent or inventor's certificate or of any PCT international applications(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

[11150/38]

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s)	:	Andreas BASTIAN et al.
Serial No.	:	09/936,412
Filed	:	Herewith
For	:	DEVICE HAVING AT LEAST ONE LASER SENSOR AND A METHOD FOR OPERATING A LASER SENSOR
Examiner	:	To Be Assigned
Art Unit	:	To Be Assigned

Assistant Commissioner for Patents
Washington, D.C. 20231

PRELIMINARY AMENDMENT AND
37 C.F.R. § 1.125 SUBSTITUTE SPECIFICATION STATEMENT

S I R:

Kindly amend the above-captioned application before examination, as set forth below.

IN THE SPECIFICATION AND ABSTRACT:

In accordance with 37 C.F.R. § 1.121(b)(3), a Substitute Specification (including the Abstract, but without claims) accompanies this response. It is respectfully requested that the Substitute Specification (including Abstract) be entered to replace the Specification of record.

IN THE CLAIMS:

On the first page of the claims, first line, change "Claims" to --WHAT IS CLAIMED IS:--.

Please cancel, without prejudice, claims 1 to 14 in the underlying PCT application. Please also cancel, without prejudice, claims 1 and 8 in the annex to the International Preliminary Examination Report.

Please add the following new claims:

--15 (New) A device for a motor vehicle, comprising:

at least one laser sensor configured to determine at least one of a position and a distance of an object in a scanning area, the laser sensor including:

a device configured to sweep at least one laser beam emitted by the laser sensor in the scanning area; and

a power supply configured to vary a power of the laser beam as a function of a beam direction.

16. (New) The device according to claim 15, wherein the power supply is configured to supply variable power to the laser sensor, the power supply being further configured to supply power to the laser sensor as a function of the laser beam direction.

17. (New) The device according to claim 16, wherein the scanning area is subdivided into segments, each segment having a different detection relevance, and wherein the power supply is configured to supply more power to a first segment having a higher detection relevance and to supply less power to a second segment having a lesser detection relevance.

18. (New) The device according to claim 15, wherein a characteristic curve of the laser beam power is continuously variable.

19. (New) The device according to claim 15, wherein at least one of a maximum power of the laser sensor and a power characteristic across the scanning area is a function of a motor vehicle speed.

20. (New) The device according to claim 15, wherein the device configured to sweep the at least one laser beam is further configured to sweep the at least one laser beam to traverse the scanning area at different scanning speeds.

21. (New) The device according to claim 15, wherein at least one of a maximum power of the at least one laser sensor and a power characteristic across the scanning area is a function of at least one of a distance of an object detected by

the laser sensor, a direction of an object detected by the laser sensor and a type of an object detected by the laser sensor.

22. (New) A method for operating a laser sensor of a motor vehicle to ascertain at least one of a position and a distance of an object in a scanning area, comprising the steps of:

sweeping at least one laser beam in the scanning area; and

varying a power of the at least one laser beam as a function of a beam direction.

23. (New) The method according to claim 22, further comprising the steps of:

subdividing the scanning area into segments, each segment having a different detection relevance; and

emitting the at least one laser beam at a higher beam power in a first segment having a higher detection relevance and at a lower beam power in a second segment having a lesser detection relevance.

24. (New) The method according to claim 23, further comprising the step of emitting the at least one laser beam at a maximum beam power in a direction of travel of the motor vehicle.

25. (New) The method according to claim 22, further comprising the step of continuously varying a beam power characteristic of the at least one laser beam.

26. (New) The method according to claim 22, further comprising the step of selecting at least one of a maximum beam power of the at least one laser beam and a power characteristic of the at least one laser beam across the scanning area as a function of a vehicle speed.

27. (New) The method according to claim 22, further comprising the step of traversing the scanning area of the laser sensor at different scanning speeds.

28. (New) The method according to claim 22, further comprising the step of selecting at least one of a maximum beam power of the at least one laser sensor

and a power characteristic across the scanning area as a function of at least one of a distance of an object detected by the laser sensor, a direction of an object detected by the laser sensor and a type of an object detected by the laser sensor.--.

REMARKS

This Preliminary Amendment cancels, without prejudice, claims 1 to 14 in the underlying PCT Application No. PCT/EP00/01936. This Preliminary Amendment further cancels, without prejudice, claims 1 and 8 in the annex to the International Preliminary Examination Report and adds new claims 15 to 28. The new claims, inter alia, conform the claims to U.S. Patent and Trademark Office rules and does not add any new matter to the application.

In accordance with 37 C.F.R. § 1.121(b)(3), the Substitute Specification (including the Abstract, but without the claims) contains no new matter. The amendments reflected in the Substitute Specification (including Abstract) are to conform the Specification and Abstract to U.S. Patent and Trademark Office rules or to correct informalities. As required by 37 C.F.R. §§ 1.121(b)(3)(iii) and 1.125(b)(2), a Marked Up Version of the Substitute Specification comparing the Specification of record and the Substitute Specification also accompanies this Preliminary Amendment. Approval and entry of the Substitute Specification (including Abstract) is respectfully requested.

The underlying PCT Application No. PCT/EP00/01936 includes an International Search Report, dated July 12, 2000, a copy of which is included. The Search Report includes a list of documents that were considered by the Examiner in the underlying PCT application.

The underlying PCT Application No. PCT/EP00/01936 also includes an International Preliminary Examination Report, dated July 5, 2001. An English translation of the International Preliminary Examination Report and annex thereto is included herewith.

It is respectfully submitted that the subject matter of the present application is new, non-obvious and useful. Prompt consideration and allowance of the application are respectfully requested.

Respectfully submitted,

KENYON & KENYON

Dated: 1/23/02

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DEVICE HAVING AT LEAST ONE LASER SENSOR AND A METHOD FOR OPERATING A LASER SENSOR

FIELD OF THE INVENTION

The present invention relates to a device for a motor vehicle, having at least one laser sensor, the laser sensor including a device for sweeping, in a scanning area, at least one laser beam that may be emitted by the laser sensor, and including a power supply for the laser sensor. The present invention also relates to a method for operating a laser sensor of a motor vehicle, in a scanning area, using at least one laser beam.

BACKGROUND INFORMATION

In automotive engineering, information regarding the presence, the distance, and possibly the speed of objects is particularly needed for various control systems. Examples of such control systems or driver-assistance devices include automatic ranging, a pre-crash sensory system that triggers the airbags in a timely manner, lane-changing devices, or park-distance control devices. In this context, various distance sensors based on different physical principles are, in turn, conventional, such as laser, radar, or ultrasound. Laser and/or radar sensors are almost exclusively used in the application field of automatic ranging sensors, a combination of sensors utilizing the specific advantages of the sensors being especially favorable. In the case of automatic ranging systems or lane-change assistance devices, a fixed, single-point scan of the front traffic space is not sufficient, but rather, a certain sector must at least be scanned in order to reliably detect an object. Such sector-shaped emission is inherent to the radar sensor because of the radiation characteristic of its antenna, whereas, in the case of a laser sensor, this must be done actively by moving the laser or an optical system. In so doing, the laser beam is successively swept across the desired sector and scans it for objects. Since safety distances as long as, for

example, 50 m are sometimes necessary, the laser must have an appropriately large range. For this purpose, the laser must have a correspondingly high intensity, i.e., it must be operated at a high beam power. However, this results in considerable power losses in the laser sensor, which must be supplied by an energy source and must be dissipated in the form of heat, using appropriate cooling measures. If passive cooling measures, such as heat sinks, do not suffice in this case, then active cooling systems requiring additional energy must be used.

On the other hand, the power output of laser sensors is limited by safety requirements for the benefit of persons in the vicinity of the vehicle, who can be struck by the laser beams and receive an eye injury due to a reflex.

German Published Patent Application No. 39 03 501 describes an optical distance-measuring device for vehicles, which includes a semiconductor laser as an emitter for the very short infrared range. The emitting capacity of the semiconductor laser is automatically adapted to the environmental conditions, especially visibility, by a signal evaluation unit, and is adjusted to conform to eye-safety requirements. The adjustment of the power output of the system is based on the received signal. This means that the emitting power of the system is a direct function of the power of the received echo signal. If an echo signal is not received, because there is no reflecting obstacle in front of the vehicle, then the default emitting power must be selected to be high, in order to cover as large an area as possible in front of the vehicle and to be able to detect obstacles in this area. Therefore, an object appearing suddenly is struck by an unnecessarily intense scanning beam. A high emitting power must also be selected in the case of poorly reflecting obstacles.

In addition, German Published Patent Application No. 197 07 936 describes a method for determining a distance of an

obstacle to a vehicle, using an optical distance sensor, where the emitting power of the distance sensor is controlled as a function of the traveling speed, in order to increase eye safety.

It is an object of the present invention to provide a device having a scanning laser sensor, and a method for operating such a device, which, on the average, consume less power over time, without losing considerable amounts of information.

SUMMARY

The present invention provides for the power output of the laser beam emitted by the laser sensor being variable as a function of the direction of the laser beam.

By varying the power input as a function of the position of the device for sweeping the laser beam, in which case the laser is supplied more power in areas of high relevance than in the less relevant areas, the average power input of the sensor is reduced, so that both the power supply itself and a potentially necessary cooling system may be dimensioned to be smaller, and at the same time, the eye safety is increased. The increased service life of the laser sensor may be regarded as a further advantage of the present invention.

An example embodiment of the present invention provides for the characteristic curve of the laser sensor's beam power being continuously varied.

Another example embodiment of the present invention provides for the maximum power of the laser sensor and/or the power characteristic across the scanning area being selected as a function of the vehicle speed.

This arrangement provides the advantage of the beam power of the laser sensor being adapted to the actual requirements of

the driving situation, and the danger to people being further reduced.

Furthermore, it may be provided that the maximum beam power of the laser sensor and/or the power characteristic across the scanning area be selected as a function of a detected object, thereby allowing both the distance of the object and, whether the object is a living thing or an article, to play a role. In particular, the location of the object with respect to the vehicle or the laser sensor is important for the characteristic of the beam power.

BRIEF DESCRIPTION OF THE DRAWING

Figure 1 is a top plan view of a scanning area of a laser-scan distance-sensing system according to the present invention.

DETAILED DESCRIPTION

The present invention is explained below in detail, using an example embodiment. Figure 1 illustrates a scanning area of a laser-scan distance-sensing system.

Illustrated in Figure 1 is a motor vehicle 1 having a scanning laser sensor 3 positioned in the front area of motor vehicle 1, the scanning laser sensor being, for example, a component of an automatic ranging system and a lane-change assistance device. Laser sensor 3 includes a transmitter unit, which emits laser radiation, and a receiving device, which receives laser radiation reflected by objects or obstacles, and may evaluate it according to propagation time and angle of incidence. In addition, laser sensor 3 includes a device configured to horizontally sweep the laser beam across a scanning range 2, which is 180° in the illustrated example embodiment of the present invention. However, scanning ranges of up to 360° are also possible. The device configured to sweep the laser beam may either swing the laser as a whole or may be in the form of a suitable optical system. The laser sensor is assigned a power supply, which allows the laser

sensor a variable power input that it converts into laser radiation. The larger the beam power made available by the energy supply, the higher the intensity and, thus, the larger the range of laser sensor 3.

In an automatic ranging system, for example, the other motor vehicles directly in front of motor vehicle 1, which must also be reliably detected from a longer distance, are of interest, whereas motor vehicles in adjacent lanes are not as interesting. For example, they are only of interest in the immediate vicinity of motor vehicle 1, in case the motor-vehicle driver plans to change lanes, and it must be checked if motor vehicles are in the desired lane, and if one may change lanes without risk. On the basis of these preconsiderations, the range of laser sensor 3 may be chosen to be smaller in the segments that the scanning area sweeps over adjacent lanes. This arrangement is illustrated in a discrete form in Fig. 1, three different segments I, II, and III having been selected. In this context, Segment I, for example, spans an scanning angle of -30° to 30°, and is used for detecting motor vehicles traveling directly in front. In this area, laser sensor 3 is operated at the highest power, and therefore, at the longest range. Segment II covers motor vehicles, which are in adjacent lanes, and may possibly move into the lane of the vehicle in question, i.e., may be taken into consideration during a lane change, this segment II spanning, for example, a scanning angle of -60° to -30° and 30° to 60°. Motor vehicles that are nearly adjacent are detected in segment III, so that a range of 4 to 5 m may be completely sufficient. Therefore, the average required power may be reduced without loss of information. In addition, the optical power sweeping over a possible, adjacent sidewalk is reduced, so that the risk of damaging the eyesight of passers-by is reduced.

Apart from a stepped reduction in the intensity, the intensity may also be reduced continuously from the mid-position, i.e.,

the intensity function $i(\alpha)$ is a continuous function. In specific example embodiments of the present invention, where two laser-scan sensors 3 are situated on the right and left, in the front area of motor vehicle 1, angular distribution $i(\alpha)$ is selected in a correspondingly different manner, so that the most relevant areas may be scanned at the highest intensity.

Since the safety distance to be kept is dependent on the speed, the laser is operated, in particular in segment I, at an intensity that increases with the speed. Another option for further variation of the intensity is to pass through the different segments at different scanning speeds. Thus, segment III, for example, may be traversed at a higher scanning speed, in order to further reduce the risk of injuring passers-by.

ABSTRACT

A device for a motor vehicle includes at least one laser sensor. The laser sensor includes a device configured to sweep a scanning area with at least one laser beam emitted by the laser sensor and a power supply device for the laser sensor. In a method for operating a laser sensor in a scanning area with at least one laser beam, the power of the laser beam emitted by the laser sensor is varied in accordance with its direction of radiation.

DEVICE HAVING AT LEAST ONE LASER SENSOR AND A METHOD FOR OPERATING A LASER SENSOR

FIELD OF THE INVENTION

The present invention relates to a device for a motor vehicle, having at least one laser sensor, the laser sensor including a device for sweeping, in a scanning area, at least one laser beam that [can] **may** be emitted by the laser sensor, and including a power supply for the laser sensor. The present invention also relates to a method for operating a laser sensor of a motor vehicle, in a scanning area, using at least one laser beam.

BACKGROUND INFORMATION

In automotive engineering, information regarding the presence, the distance, and possibly the speed of objects is particularly needed for various control systems. Examples of such control systems or driver-assistance devices include automatic ranging, a pre-crash sensory system that triggers the airbags in a timely manner, lane-changing devices, or park-distance control devices. In this context, various distance sensors based on different physical principles are, in turn, [known] **conventional**, such as laser, radar, or ultrasound. Laser and/or radar sensors are almost exclusively used in the application field of automatic ranging sensors, a combination of sensors utilizing the specific advantages of the sensors being especially favorable. In the case of automatic ranging systems or lane-change assistance devices, a fixed, single-point scan of the front traffic space is not sufficient, but rather, a certain sector must at least be scanned in order to reliably detect an object. Such sector-shaped emission is inherent to the radar sensor because of the radiation characteristic of its antenna, whereas, in the case of a laser sensor, this must be done actively by moving the laser or an optical system. In so doing, the laser

beam is successively swept across the desired sector and scans it for objects. Since safety distances as long as, for example, 50 m are sometimes necessary, the laser must have an appropriately large range. For this purpose, the laser must have a correspondingly high intensity, i.e., it must be operated at a high beam power. However, this results in considerable power losses in the laser sensor, which must [first of all] be supplied by an energy source[,] and [secondly,] must be dissipated in the form of heat, using appropriate cooling measures. If passive cooling measures, such as heat sinks, do not suffice in this case, then active cooling systems requiring additional energy must be used.

On the other hand, the power output of laser sensors is limited by safety requirements for the benefit of persons in the vicinity of the vehicle, who can be struck by the laser beams and receive an eye injury due to a reflex.

[Therefore DE] **German Published Patent Application No.** 39 03 501 [proposes] **describes** an optical distance-measuring device for vehicles, which includes a semiconductor laser as an emitter for the very short infrared range[; on one hand, the]**. The** emitting capacity of the semiconductor laser [being] **is** automatically adapted to the environmental conditions, especially visibility, by a signal evaluation unit, and [on the other hand, it being] **is** adjusted to conform to eye-safety **requirements**. [In the related art, the] **The** adjustment of the power output of the system is based on the received signal. This means that the emitting power of the system is a direct function of the power of the received echo signal. If an echo signal is not received [from there], because there is no reflecting obstacle in front of the vehicle, then the default emitting power must be selected to be high, in order to cover as large an area as possible in front of the vehicle[,] and to be able to detect obstacles in this area. Therefore, an object appearing suddenly is struck

by an unnecessarily intense scanning beam. A high emitting power must also be selected in the case of poorly reflecting obstacles.

In addition, [DE] **German Published Patent Application No.** 197 07 936 [A1 proposes] **describes** a method for determining a distance of an obstacle to a vehicle, using an optical distance sensor, where the emitting power of the distance sensor is controlled as a function of the traveling speed, in order to increase eye safety.

[The] **It is an** object of the present invention [is] to provide a device having a scanning laser sensor, and a method for operating such a device, which, on the average, consume less power over time, without losing considerable amounts of information.

SUMMARY

[The solution of the engineering problem follows from the features of Claims 1 and 8.]

The present invention provides for the power output of the laser beam emitted by the laser sensor being variable as a function of the direction of the laser beam.

By varying the power input as a function of the position of the device for sweeping the laser beam, in which case the laser is supplied more power in areas of high relevance than in the less relevant areas, the average power input of the sensor is reduced, so that [on one hand,] both the power supply itself and a potentially necessary cooling system [can] **may** be dimensioned to be smaller, and at the same time, the eye safety is increased. The increased service life of the laser sensor [can] **may** be regarded as a further advantage of the present invention.

[Additional advantageous refinements follow from the dependent claims.]

An [advantageous] example **embodiment of the present invention** provides for the characteristic curve of the laser sensor's beam power being continuously varied.

Another [specific] **example** embodiment **of the present invention** provides for the maximum power of the laser sensor and/or the power characteristic across the scanning area being selected as a function of the vehicle speed[, as well].

This [has] **arrangement provides** the advantage of the beam power of the laser sensor [always] being adapted to the actual requirements of the driving situation, and the danger to people being further reduced.

Furthermore, it [can] **may** be provided that the maximum beam power of the laser sensor and/or the power characteristic across the scanning area be selected as a function of a detected object, thereby allowing both the distance of the object and, whether the object is a living thing or an article, to play a role. In particular, the location of the object with respect to the vehicle or the laser sensor is important for the characteristic of the beam power.

BRIEF DESCRIPTION OF THE DRAWING

Figure 1 is a top plan view of a scanning area of a laser-scan distance-sensing system according to the present invention.

DETAILED DESCRIPTION

The present invention is explained below in detail, using [a preferred exemplary] **an example** embodiment. [The one figure shows] **Figure 1 illustrates** a scanning area of a laser-scan distance-sensing system.

[Represented] **Illustrated** in Figure 1 is a motor vehicle 1 having a scanning laser sensor 3 positioned in the front area of motor vehicle 1, the scanning laser sensor being, for example, a component of an automatic ranging system and a lane-change assistance device. Laser sensor 3 includes a transmitter unit [not shown], which emits laser radiation, and a receiving device [also not shown], which receives laser radiation reflected by objects or obstacles, and [can] **may** evaluate it according to propagation time and angle of incidence. In addition, laser sensor 3 includes a device [for] **configured to** horizontally [sweeping] **sweep** the laser beam across a scanning range 2, which is 180° in the [represented] **illustrated** example **embodiment of the present invention**. However, scanning ranges of up to 360° are also [conceivable] **possible**. The device [for sweeping] **configured to sweep** the laser beam [can] **may** either swing the laser as a whole[,] or [is] **may be** in the form of a suitable optical system. The laser sensor is assigned a power supply, which allows the laser sensor a variable power input that it converts into laser radiation. The larger the beam power made available by the energy supply, the higher the intensity and, thus, the larger the range of laser sensor 3.

In an automatic ranging system, for example, the other motor vehicles directly in front of motor vehicle 1, which must also be reliably detected from a longer distance, are of interest, whereas motor vehicles in adjacent lanes are not as interesting. For example, they are only of interest in the immediate vicinity of motor vehicle 1, in case the motor-vehicle driver plans to change lanes, and it must be checked if motor vehicles are in the desired lane, and if one [can] **may** change lanes without risk. On the basis of these preconsiderations, the range of laser sensor 3 [can] **may** be chosen to be smaller in the segments[, where] **that** the scanning area sweeps over adjacent lanes. This **arrangement** is

[represented] **illustrated** in a discrete form in Fig. 1, three different segments I, II, and III having been selected. In this context, Segment I, for example, spans an scanning angle of -30° to 30°, and is used for detecting motor vehicles traveling directly in front. In this area, laser sensor 3 is operated at the highest power, and therefore, at the longest range. Segment II covers motor vehicles, which are in adjacent lanes, and [could] **may** possibly move into the lane of the vehicle in question, i.e. [should]**, may** be taken into consideration during a lane change, this segment II spanning, for example, a scanning angle of -60° to -30° and 30° to 60°. Motor vehicles that are nearly adjacent are detected in segment III, so that a range of 4 to 5 m [is] **may be** completely sufficient. Therefore, the average required power [can] **may** be reduced without loss of information. In addition, the optical power sweeping over a possible, adjacent sidewalk is reduced, so that the risk of damaging the eyesight of passers-by is reduced.

Apart from a stepped reduction in the intensity, the intensity [can] **may** also be reduced continuously from the mid-position, i.e.**,** the intensity function i(α) is a continuous function. In specific **example** embodiments **of the present invention**, where two laser-scan sensors 3 are situated on the right and left, in the front area of motor vehicle 1, angular distribution i(α) is selected in a correspondingly different manner, so that the most relevant areas [can again] **may** be scanned at the highest intensity.

Since the safety distance to be kept is dependent on the speed, the laser is operated, in particular in segment I, at an intensity that increases with the speed. Another option for further variation of the intensity is to pass through the different segments at different scanning speeds. Thus, segment III, for example, [can] **may** be traversed at a higher

scanning speed, in order to further reduce the risk of injuring passers-by.

ABSTRACT

A device for a motor vehicle includes at least one laser sensor. The laser sensor includes a device configured to sweep a scanning area with at least one laser beam emitted by the laser sensor and a power supply device for the laser sensor. In a method for operating a laser sensor in a scanning area with at least one laser beam, the power of the laser beam emitted by the laser sensor is varied in accordance with its direction of radiation.

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[11150/38]

DEVICE HAVING AT LEAST ONE LASER SENSOR AND A METHOD FOR OPERATING A LASER SENSOR

The present invention relates to a device for a motor vehicle, having at least one laser sensor, the laser sensor including a device for sweeping, in a scanning area, at least one laser beam that can be emitted by the laser sensor, and including a power supply for the laser sensor. The present invention also relates to a method for operating a laser sensor of a motor vehicle, in a scanning area, using at least one laser beam.

In automotive engineering, information regarding the presence, the distance, and possibly the speed of objects is particularly needed for various control systems. Examples of such control systems or driver-assistance devices include automatic ranging, a pre-crash sensory system that triggers the airbags in a timely manner, lane-changing devices, or park-distance control devices. In this context, various distance sensors based on different physical principles are, in turn, known, such as laser, radar, or ultrasound. Laser and/or radar sensors are almost exclusively used in the application field of automatic ranging sensors, a combination of sensors utilizing the specific advantages of the sensors being especially favorable. In the case of automatic ranging systems or lane-change assistance devices, a fixed, single-point scan of the front traffic space is not sufficient, but rather, a certain sector must at least be scanned in order to reliably detect an object. Such sector-shaped emission is inherent to the radar sensor because of the radiation characteristic of its antenna, whereas, in the case of a laser sensor, this must be done actively by moving the laser or an optical system. In so doing, the laser beam is successively swept across the desired sector and scans it for objects. Since safety distances as long as, for example, 50 m are sometimes necessary, the laser must have an appropriately large range. For this purpose, the laser must

have a correspondingly high intensity, i.e. it must be operated at a high beam power. However, this results in considerable power losses in the laser sensor, which must first of all be supplied by an energy source, and secondly, must be dissipated in the form of heat, using appropriate cooling measures. If passive cooling measures, such as heat sinks, do not suffice in this case, then active cooling systems requiring additional energy must be used.

On the other hand, the power output of laser sensors is limited by safety requirements for the benefit of persons in the vicinity of the vehicle, who can be struck by the laser beams and receive an eye injury due to a reflex.

Therefore DE 39 03 501 proposes an optical distance-measuring device for vehicles, which includes a semiconductor laser as an emitter for the very short infrared range; on one hand, the emitting capacity of the semiconductor laser being automatically adapted to the environmental conditions, especially visibility, by a signal evaluation unit, and on the other hand, it being adjusted to conform to eye-safety. In the related art, the adjustment of the power output of the system is based on the received signal. This means that the emitting power of the system is a direct function of the power of the received echo signal. If an echo signal is not received from there, because there is no reflecting obstacle in front of the vehicle, then the default emitting power must be selected to be high, in order to cover as large an area as possible in front of the vehicle, and to be able to detect obstacles in this area. Therefore, an object appearing suddenly is struck by an unnecessarily intense scanning beam. A high emitting power must also be selected in the case of poorly reflecting obstacles.

In addition, DE 197 07 936 A1 proposes a method for determining a distance of an obstacle to a vehicle, using an optical distance sensor, where the emitting power of the

distance sensor is controlled as a function of the traveling speed, in order to increase eye safety.

The object of the present invention is to provide a device having a scanning laser sensor, and a method for operating such a device, which, on the average, consume less power over time, without losing considerable amounts of information.

The solution of the engineering problem follows from the features of Claims 1 and 8.

The present invention provides for the power output of the laser beam emitted by the laser sensor being variable as a function of the direction of the laser beam.

By varying the power input as a function of the position of the device for sweeping the laser beam, in which case the laser is supplied more power in areas of high relevance than in the less relevant areas, the average power input of the sensor is reduced, so that on one hand, both the power supply itself and a potentially necessary cooling system can be dimensioned to be smaller, and at the same time, the eye safety is increased. The increased service life of the laser sensor can be regarded as a further advantage of the present invention.

Additional advantageous refinements follow from the dependent claims.

An advantageous embodiment provides for the characteristic curve of the laser sensor's beam power being continuously varied.

Another specific embodiment provides for the maximum power of the laser sensor and/or the power characteristic across the scanning area being selected as a function of the vehicle speed, as well.

This has the advantage of the beam power of the laser sensor always being adapted to the actual requirements of the driving situation, and the danger to people being further reduced.

Furthermore, it can be provided that the maximum beam power of the laser sensor and/or the power characteristic across the scanning area be selected as a function of a detected object, thereby allowing both the distance of the object and, whether the object is a living thing or an article, to play a role. In particular, the location of the object with respect to the vehicle or the laser sensor is important for the characteristic of the beam power.

The present invention is explained below in detail, using a preferred exemplary embodiment. The one figure shows a scanning area of a laser-scan distance-sensing system.

Represented in Figure 1 is a motor vehicle 1 having a scanning laser sensor 3 positioned in the front area of motor vehicle 1, the scanning laser sensor being, for example, a component of an automatic ranging system and a lane-change assistance device. Laser sensor 3 includes a transmitter unit not shown, which emits laser radiation, and a receiving device also not shown, which receives laser radiation reflected by objects or obstacles, and can evaluate it according to propagation time and angle of incidence. In addition, laser sensor 3 includes a device for horizontally sweeping the laser beam across a scanning range 2, which is 180° in the represented example. However, scanning ranges of up to 360° are also conceivable. The device for sweeping the laser beam can either swing the laser as a whole, or is in the form of a suitable optical system. The laser sensor is assigned a power supply, which allows the laser sensor a variable power input that it converts into laser radiation. The larger the beam power made available by the energy supply, the higher the intensity and, thus, the larger the range of laser sensor 3.

In an automatic ranging system, for example, the other motor vehicles directly in front of motor vehicle 1, which must also be reliably detected from a longer distance, are of interest, whereas motor vehicles in adjacent lanes are not as interesting. For example, they are only of interest in the immediate vicinity of motor vehicle 1, in case the motor-vehicle driver plans to change lanes, and it must be checked if motor vehicles are in the desired lane, and if one can change lanes without risk. On the basis of these preconsiderations, the range of laser sensor 3 can be chosen to be smaller in the segments, where the scanning area sweeps over adjacent lanes. This is represented in a discrete form in Fig. 1, three different segments I, II, and III having been selected. In this context, Segment I, for example, spans an scanning angle of -30° to 30°, and is used for detecting motor vehicles traveling directly in front. In this area, laser sensor 3 is operated at the highest power, and therefore, at the longest range. Segment II covers motor vehicles, which are in adjacent lanes, and could possibly move into the lane of the vehicle in question, i.e. should be taken into consideration during a lane change, this segment II spanning, for example, a scanning angle of -60° to -30° and 30° to 60°. Motor vehicles that are nearly adjacent are detected in segment III, so that a range of 4 to 5 m is completely sufficient. Therefore, the average required power can be reduced without loss of information. In addition, the optical power sweeping over a possible, adjacent sidewalk is reduced, so that the risk of damaging the eyesight of passers-by is reduced.

Apart from a stepped reduction in the intensity, the intensity can also be reduced continuously from the mid-position, i.e. the intensity function $i(\alpha)$ is a continuous function. In specific embodiments, where two laser-scan sensors 3 are situated on the right and left, in the front area of motor vehicle 1, angular distribution $i(\alpha)$ is selected in a

correspondingly different manner, so that the most relevant areas can again be scanned at the highest intensity.

Since the safety distance to be kept is dependent on the speed, the laser is operated, in particular in segment I, at an intensity that increases with the speed. Another option for further variation of the intensity is to pass through the different segments at different scanning speeds. Thus, segment III, for example, can be traversed at a higher scanning speed, in order to further reduce the risk of injuring passers-by.

Claims

1. A device for a motor vehicle (1), having at least one laser sensor (3), the laser sensor (3) comprising a device for sweeping, in a scanning area (2), at least one laser beam that can be emitted by the laser sensor (3), and comprising a power supply for the laser sensor, wherein the power of the laser beam that can be emitted by the laser sensor (3) can be varied as a function of the laser-beam direction.

2. The device as recited in Claim 1, wherein the power, which can be supplied to the laser sensor (3) by the power supply, is variable and can be supplied as a function of the laser-beam direction.

3. The device as recited in Claim 2, wherein the scanning area (2) of the laser sensor is subdivided into segments (I, II, III) of different relevance, and the laser sensor can be supplied more power in segments (I) of higher detection relevance, and less power in areas (II, III) of lesser detection relevance.

4. The device as recited in one of Claims 1 through 3, wherein the characteristic curve (α) of the power varies continuously.

5. The device as recited in one of Claims 1 through 4, wherein the maximum power of the laser sensor (3) and/or the power characteristic across the scanning area (2) can be selected as a function of the motor-vehicle speed.

6. The device as recited in one of Claims 1 through 5, wherein the scanning area (2) of the laser sensor (3) can be traversed at different scanning speeds.

7. The device as recited in one of Claims 1 through 6, wherein the maximum power of the laser sensor and/or the power characteristic across the scanning area (2) can be selected as a function of the distance of the, and/or the direction of the, and/or the type of object detected by the laser sensor.

8. A method for operating a laser sensor (3) of a motor vehicle (1), in a scanning range (2), using at least one laser beam,
wherein the emitting power of the at least one laser beam is varied as a function of its beam direction.

9. The method as recited in Claim 8,
wherein the scanning area (2) of the laser sensor is subdivided into segments (I, II, III) of different detection relevance, and the at least one laser beam can be emitted at a higher beam power in segments (I) of higher detection relevance, and at a lower beam power in segments (II, III) of lesser detection relevance.

10. The method as recited in Claim 9,
wherein the at least one laser beam is emitted at maximum beam power, in the direction of travel of the motor vehicle (1).

11. The method as recited in one of Claims 8 through 10, wherein the beam-power characteristic of the least one laser beam varies continuously.

12. The method as recited in one of Claims 8 through 11, wherein the maximum beam power of the at least one laser beam and/or the power characteristic of the at least one laser beam across the scanning area (2) is selected as a function of the vehicle speed.

13. The method as recited in one of Claims 8 through 12,

wherein the scanning area (2) of the laser sensor (3) is traversed at different scanning speeds.

14. The device as recited in one of Claims 8 through 13, wherein the maximum beam power of the at least one laser sensor and/or the power characteristic across the scanning area (2) is selected as a function of the distance of the, and/or the direction of the, and/or the type of object detected by the laser sensor (3).

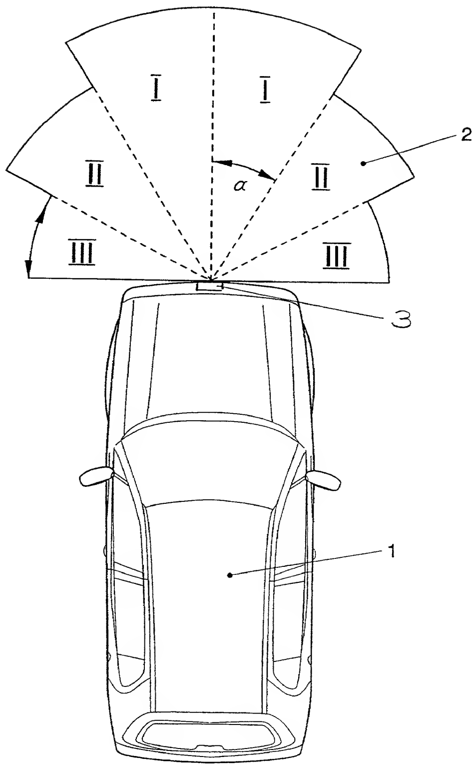

FIG. 1

PRIOR FOREIGN/PCT APPLICATION(S)
AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. § 119

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Priority Claimed
Under 35 U.S.C. § 119: [X] Yes [ ] No

I hereby claim the benefit under Title 35, United States Code § 120 of any United States Application or PCT International Application designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations § 1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

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